

Review T3 Waves and Sounds

1. Herr Gardner's radio show is on 91.7 MHz every Saturday night. What is the wavelength of these waves?

$$v = f\lambda$$

$$3 \times 10^8 \text{ m/s} = (91.7 \times 10^6 \text{ Hz})(\lambda)$$

$$\lambda = \frac{300,000,000}{91,700,000} \text{ meters} = \boxed{3.27 \text{ meters}}$$

2. A guitar string has a length of 1.20 meters with a fundamental frequency of 250 Hz and a linear density of $5.5 \times 10^{-4} \text{ kg/m}$. What is the tension of the string?

$$v_{string} = \sqrt{\frac{\text{tension}(N)}{\text{linear density}(kg/m)}}$$

$$v_{string} = f\lambda$$

$$\text{therefore } \sqrt{\frac{\text{tension}(N)}{\text{linear density}(kg/m)}} = f\lambda$$

$$\sqrt{\frac{\text{tension}}{5.5 \times 10^{-4} \text{ kg/m}}} = 250 \text{ Hz } (\lambda)$$

$$\sqrt{\frac{\text{tension}}{5.5 \times 10^{-4}}} = 250(\lambda)$$

$$\sqrt{\text{tension}} = \sqrt{5.5 \times 10^{-4}}(250)(\lambda)$$

$$\sqrt{\text{tension}} = 5.863\lambda$$

$$\text{tension} = 34.375\lambda^2$$

We know that $\ell_{string} = \frac{1}{2}\lambda$. We can rearrange to get $\lambda = 2\ell_{string}$, so $\lambda = 2.4 \text{ m}$

Plugging that back in we get $tension = 34.375(2.4)^2$, and $tension = \boxed{198N}$

3. What is the length of a tube open at both ends with the same fundamental frequency as the guitar string from the previous problem? Assume the speed of sound is 340m/s.

$$v = f\lambda$$

$$340m/s = 250\text{Hz}(\lambda)$$

$$\ell = \frac{1}{2}\lambda, \text{ so } \lambda = 2\ell$$

Plugging in λ , we get $340 = 250(2\ell)$, so $\boxed{\ell = 0.68m}$

4. A tuning fork of an unknown frequency produces 6 beats per second when sounded with a 440Hz tuning fork. The beat frequency is greater when the unknown fork is sounded with a 430 Hz tuning fork. What is the frequency of the unknown fork?

Remember that beats per second is calculated with the expression $|f_1 - f_2|$, where f_1 and f_2 are the two frequencies vibrating simultaneously.

We know $|f_{unknown} - 440\text{Hz}| = 6\text{Hz}$, so $f_{unknown} = 434\text{Hz}$ or 446Hz .

But since the beat frequency is greater with the 430Hz fork, then $f_{unknown}$ must be $\boxed{446\text{Hz}}$

FORMULAS:

The Wave Equation:

$$\boxed{v = f\lambda}$$

Velocity of Sound travelling through a string under tension (T):

$$v = \sqrt{\frac{T}{\text{linear density}}}$$

Frequency of any harmonic in a closed tube of length ℓ :

$$v = f\lambda$$

$$\ell = \frac{n}{4}\lambda, \text{ so } \lambda = \frac{4\ell}{n}$$

$$v = f \frac{4\ell}{n}, \text{ therefore } f = \frac{nv}{4\ell}$$

Frequency of any harmonic in an open tube of length ℓ :

$$v = f\lambda$$

$$\ell = \frac{n}{2}\lambda, \text{ so } \lambda = \frac{2\ell}{n}$$

$$v = f \frac{2\ell}{n}, \text{ therefore } f = \frac{nv}{2\ell}$$

Length of a string vibration at the third overtone:

$$\ell = \frac{n}{2}\lambda, \text{ so } \ell = \frac{3}{2}\lambda$$

5. The tension on the 1.6 meter long wire is 135.0 N. The wire has a total mass of 0.008kg. What is the frequency of the THIRD OVERTONE produced by the wire?

$$\text{Linear Density: } \frac{0.008\text{kg}}{1.6\text{m}} = 0.005\text{kg/m}$$

$$\sqrt{\frac{\text{tension}}{\text{linear density}}} = f\lambda$$

$$\sqrt{\frac{135\text{N}}{0.005\text{kg/m}}} = f\lambda$$

$$\ell = \frac{n}{2}\lambda, \text{ so for the third harmonic, } \ell = \frac{3}{2}\lambda, \text{ so } \lambda = \frac{2}{3}\ell$$

$$\text{Plugging this in, we get } \sqrt{\frac{135N}{0.005kg/m}} = f\left(\frac{2}{3}\right)(1.6m).$$

$$164.317 = 1.067f, \text{ therefore, } f = 154.05Hz$$

6. What is the wavelength of the next harmonic produced by the 1.6 meter wire shown above?

We know that $\ell = \frac{n}{2}\lambda$. Knowing that this is the fourth harmonic, the equation becomes $\ell = 2\lambda$.

$$\ell = 1.6m, \text{ so } \lambda = 0.8m.$$

7. What is the fundamental frequency of a 0.8 meter closed pipe?

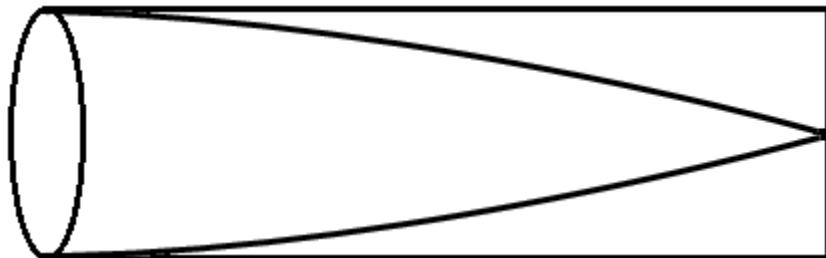
We know that for a closed pipe, $\ell = \frac{n}{4}\lambda$, so for the fundamental frequency, $\ell = \frac{1}{4}\lambda$.

Plugging in ℓ as $0.8m$, we get $\lambda = 3.2m$.

$$v = f\lambda$$

$$340m/s = f(3.2m), \text{ so } f = 106.25Hz$$

8.



9. What is the fundamental frequency of a 0.8 meter open pipe?

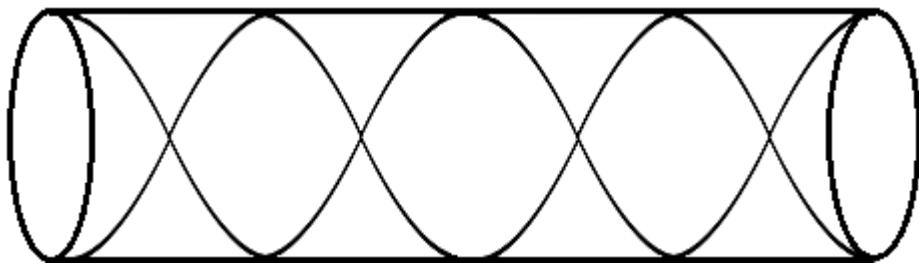
$\ell = \frac{n}{2} \lambda$, so $\lambda = 2\ell$. Substituting, we get $\lambda = 2(0.8m) = 1.6m$

$$v = f\lambda$$

$$340m/s = f(1.6m)$$

$$f = 212.5Hz$$

10.



11. Write the electromagnetic spectrum starting from the longest wavelength.

Radio Waves \rightarrow Microwaves \rightarrow Infared \rightarrow Visible Light \rightarrow UV \rightarrow X-Rays \rightarrow Gamma Rays

Visible light: Red \rightarrow Orange \rightarrow Yellow \rightarrow Green \rightarrow Blue \rightarrow Violet